

Original Article

Effect of lumbar intervertebral bone grafting combined with internal fixation in the treatment of lumbar spinal stenosis and instability

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Abstract: Objective: This study was designed to analyze the different effects of lumbar intervertebral bone grafting combined with internal fixation, and intertransverse bone grafting combined with internal fixation in patients with LST and instability. Methods: In total, 38 patients diagnosed with LST and instability, who were admitted to our hospital from February 2016 to December 2018 were included, retrospectively analyzed, and divided into 2 groups by a Random Number Table. The Control Group (CG, N=19) adopted intertransverse bone grafting combined with internal fixation, while the Observation Group (OG, n=19) were treated by Lumbar intervertebral bone grafting combined with internal fixation. The 2 groups were compared for treatment effects. Results: (1) No significant difference was observed between the 2 groups for operation time, drainage tube indwelling time, intraoperative bleeding volume and postoperative drainage volume ($P>0.05$). (2) For bone grafting, the firm fusion rate, possible fusion rate and non-fusion rate were 84.21%, 10.53% and 5.26% respectively, in the OG; 63.16%, 26.32% and 10.53% respectively, in the CG ($P>0.05$). (3) The OG reported an internal implant failure of 5.26%, and loss rate of intervertebral space height of 5.26%; while in the CG, they were 15.79% and 21.05% ($P>0.05$) respectively. (4) The OG reported higher JOA scores and lower ODI scores as compared with the CG at 1 week, 1 month, 3 months and 6 months after the operation ($P<0.05$). (5) The OG yielded a better score for quality of life (QOL) at 3 and 6 months after the operation ($P<0.05$). Conclusion: Both intertransverse bone grafting combined with internal fixation, and lumbar intervertebral bone grafting combined with internal fixation are effective against LST and instability. In comparison, the 2nd method is more promising as it can improve fusion rate, lumbar function, and QOL, and reduce internal implant failure.

Keywords: LST, instability, lumbar intervertebral bone grafting combined with internal fixation, intertransverse bone grafting combined with internal fixation, treatment

Introduction

Lumbar spinal stenosis (LST) is a narrowing of the effective volumes within the intervertebral foramen of the lumbar vertebra, the nerve root canals, and the central canal which can put pressure on the nerve roots and cauda equine, leading to syndromes at one side of one's body [1]. Lumbar instability is defined as reduced rigidity and stability of the lumbar motion segment, which leads to more significant mutual motion degrees than normal motions, and consequently more significant displacement [2]. Patients with lumbar instability will suffer from pains, rachiterata and neurothlipsis due to the loss of instability after motions [3].

Lumbar instability is a result of intervertebral disc regression, and a cause of spinal canal stenosis. It often leads to abnormal centrum motion, increased intervertebral motion, thinning cartilages of facet joints with fibrosis changes, friction of subchondral bone where corpus liberum may even be observed in the worst case [4]. Due to chronic strain, the synovium thickens gradually while the capsular ligament inflames and shows traces of hyperplasia and fibrosis due to repeated dragging [5]. In the meantime, the intervertebral disc is lowered and the intervertebral space is narrowed. Consequently, the facet joints between centrams overlap with each other seriously, leading to clearly thickened ligamentum flavum,

narrowed canalis spinalis and foramen intervertebrale. As a result, LST is often accompanied with lumbar instability [6].

Henceforth, for such a group of patients, active decompression therapy is important, which is more commonly known as the lumbar decompression and fusion. Both lumbar intervertebral bone grafting combined with internal fixation and intertransverse bone grafting combined with internal fixation have applications in clinic [7]. This study included 38 patients diagnosed with LST and instability, and were admitted to our hospital from February 2016 to December 2018 to demonstrate the difference of the 2 operations in application value.

Materials and methods

Materials

There were 38 patients diagnosed with LST and instability, who were admitted to our hospital from February 2016 to December 2018 that were retrospectively analyzed, and divided into 2 groups based on a Random Number Table. The CG included 19 patients aged between 36 and 73 with a course of disease between 2 months and 30 years, of whom, 8 were concurrently suffering from other diseases; in the OG, there were 19 cases with an age range of 37-71, a course of disease between 4 months and 30 years, of whom, 7 were concurrently suffering from other diseases. (1) Inclusion criteria: patients included were older than 18 and younger than 80. They complied with the diagnosis criteria for LST [8] and lumbar instability [9], received 1.5 months' conservative treatment, which failed however, and thus needed operative therapy initiatively after satisfying the surgical indications. All patients have given their informed consent to participate in the study which has been approved by the ethical committee of our hospital. (2) Exclusion criteria: some patients were excluded as they had osphyalgia with symptoms of root reflexes of lower extremities, more than 1 lumber segment demanding surgical treatment, osteoporosis, fracture of lumbar vertebra, other diseases which rendered them unable to tolerate the surgery, or alleosis which made them unable to cooperate with the scale evaluation.

Methods

Patients in the OG received posterior lumbar spinal canal decompression, intervertebral bone grafting and internal fixation, which included following specific steps: (1) After general anesthesia, the patients lay prostrate with an arched brace beneath the belly to properly raise the space between the spinous process and the vertebral plate, and to ensure the belly is in a suspended status with little compression and reduced pressure. The area 15 cm around the incision was disinfected, dressed, and filmed for temporary protection. (2) With the space between L4 and L5 as the central point, a longitudinal incision of about 8 cm long was made beginning at the middle long line of the waist. In an orderly fassion, the skin and lum-bodorsal fascia were cut open, followed by the spinous process from the ligamenta supraspinala at the middle. Underneath the spinous process and the lamina periosteum, muscle insertions on both sides were separated and filled with telae to stop bleeding. Then the segmental lamina and the facet joints were applied with a decompression operation and exposed thoroughly. The erector spinae insertions underneath the periosteum were bluntly cut and isolated from the left side outward-forwardly to expose the corresponding crista lambdoidalis, facet joints and vertebral plates on both sides, during which, no damage will be caused to the capsular ligament and the surrounding ligament tissues. (3) Under the guide of a C-arm x-ray machine, the centnums are to be fixed and the intervertebral space to be decompressed were identified, and pedicle screws were positioned and implanted into L5. As the L4 entry points were established, the nail path was prepared, and as the wall of the nail path 5 was secured, the positioning needle was inserted into it, and then removed for reaming after appropriate threading. The path depth, and the intactness of the nail path 5 were judged, after which, pedicle screws were fastened at the preset direction and length determined by the CT, and an anterioposterior and lateral film was taken by the X-machine to make sure the position and depth of the pedicle screws fastened. (4) Decompression of spinal canal. The depression range was determined according to patients' specific conditions and the examination results. Afterward, the L4 vertebral plate, spinous process, and the intervertebral ligamen-

tum flavum as well as 1/3 of the condyloideus mandibulae Processus underneath the L4 from the inner side were removed. Crypts on both sides were potentially expanded to completely expose the nerve root, dural sac, and back-side annulus fibrosus. (5) Decompression of the intervertebral space. The lower edges of the L4 spinous process and the vertebral plate were nipped off, the intervertebral ligamentum flavum was removed to completely expose the dural sac. If, according to the examination results with an X-machine, the vertebral plate was clearly expanding, the condyloideus mandibulae Processus underneath the left L4 was removed to further expand the nerve root canal. If the X-machine showed that the L4 intervertebral disc had protruded to the posterior position, and the nerve root adjoined with the dural sac, necessary separation was required to make sure they were not compressed. The left traveling root and exiting root were protected with cotton pads. The L4 interstitial annulus fibrosus and ligamenta longitudinale posterius were cut open in a rectangle form, the intervertebral disc tissues were removed thoroughly, and the cartilage soleplate was scraped with a soleplate scraper until slight bleeding. Trial molding of the intervertebral space height was carried out to find the proper interbody fusion cage. (6) Preparation of implanting space. The L4 interspace of lumbar vertebrae was braced with a specific expander, and the nucleus pulposus therein was removed at conditions permit. A curette was inserted into the opposite intervertebral space and rotated at 2 directions to thoroughly remove the rest intervertebral disc tissues until the cartilage soleplate was scraped with a soleplate scraper with slight bleeding. The other side was treated by the same way. (7) Intervertebral bone grafting and implantation of interbody infusion cage. A proper interbody infusion cage was selected based on the specific conditions of the patients. The lumbar curvature was corrected, the intervertebral space height was recovered, and the spinous processes as well as the bone grains of the vertebra were trimmed to judge the bone graft required. If no sufficient bone graft was available, additional materials were sourced from the ilium. With the help of a funnel, the lateral side of the centrums and the front edge of the space were filled with broken bone blocks, and an inserter was used to incline the intervertebral infusion cage filled with loose

bones to the intervertebral space, and the same side was filled with rest bone grains with the funnel. (8) Fixation. Connecting rods were installed on both sides, and the hold-down bars were pre-bended according to the measured lumbar Cobb angle before the operation to assist the recovery of physiological lumbar curvature. The bars were secured with screws, and acknowledged through an X machine. (9) The last step was stopping bleeding, inventory of appliances, equipment and telae. One drainage tube was indwelled. The incision was routinely sutured as the end of the operation.

For patients in the CG, posterior lumbar spinal canal decompression, intertransverse bone grafting combined with internal fixation were given the same anaesthetization mode, body posture, implantation of pedicle screw during the operation, decompression, fixation and hemostasis methods. The differences were, in intertransverse bone grafting, after the intertransverse muscles on both sides were separated, the intertransverse surface was made coarse by an osteotome, the removed vertebral plate and spinous process were trimmed to a strip form. The intertransverse bone grafting amount was evaluated, and then the broken bone blocks were implanted into the space between the Processus transverses on both sides to build a bridge.

Observation indicators

(1) Surgical conditions: the 2 groups were compared for operation time, intraoperative bleeding volume, postoperative drainage volume, and drainage tube indwelling time.

(2) Graft infusion: divided into 3 grades based on the infusion conditions: firm infusion: the infused site has a continuous bone trabecula, and the relative motion between segments is less than 4° based on dynamic scanning with an X machine; possible infusion: it is impossible to find a continuous bone trabecula at the infusion site clearly, and the relative motion between segments is less than 4° based on dynamic scanning with an X machine; non-infusion: no continuous bone trabecula was observed as the infused site, and the relative motion between segments exceeds 4° according to the X-machine through dynamic scanning.

Table 1. Comparison between the OG and the CG for General Materials ($\bar{x} \pm s$)/[n (%)]

Materials		OG (n=19)	CG (n=19)	t/X ²	P
Gender	Male	9 (47.37)	7 (36.84)	0.432	0.511
	Female	10 (52.63)	12 (63.16)		
Age (y)		52.13±10.19	53.35±10.51	0.363	0.719
Course of disease (y)		7.85±3.62	8.01±3.66	0.135	0.893
Parting	Type I	14 (73.68)	13 (68.42)	0.128	0.721
	Type II	5 (26.32)	6 (31.58)		
Concurrent diseases	Concurrent	7 (36.84)	8 (42.11)	0.110	0.740
	Non-concurrent	12 (63.16)	11 (57.89)		

(3) Internal grafting failure: criteria: after operation, the cage prolapses, the nail path loosens or the nail bar breaks, etc.

(4) Loss of intervertebral space height: the intervertebral height was measured at the end of surgery and 6 months after the operation. The 6-month loss rate of intervertebral space height was calculated based on the 2 measurements according to the formula of (intervertebral height measured at the end of the operation-intervertebral height measured 6 months after the operation) intervertebral height measured at the end of the operation $\times 100\%$.

(5) Lumbar function: this item was evaluated with the evaluation benchmark of waist pain treatment performance (JOA) [10] before, 1 week, 1 month, 3 months and 6 months after the operation. The evaluation consists of subjective syndromes (9 points), clinical vital signs (6 points), limit of day-to-day activities (14 points) and bladder function (-6 to 0 point), and values 29 points in total. A higher point score indicates better lumbar function.

(6) Dysfunction: Oswestry Disability Index Questionnaire (ODI) [11] was used for the evaluation before, 1 week, 1 month, 3 months and 6 months after the operation. The Questionnaire is designed with several items, including pain intensity, self-care ability in daily life, carrying things, walking, sitting, standing, disturbance to sleep, sexual life, social life, and tourism. Each item is graded between 0 and 5 and scored between 0 and 50. A higher point represents clearer dysfunction.

(7) QOL: this item was evaluated with the Short-Form 36-Item Health Survey [12] before, 3 months and 6 months after the operation. It contains 36 questions involving 8 aspects such

as physiological function, physiological role, body pain, overall health, spirits, social function, emotional role and mental health. Each question is assigned with a grade between 1 and 6, and a point between 36 and 216. A higher point score reflects better quality of life.

Statistical analysis

Statistical analysis was performed with SPSS 22.0. In case of numerical data expressed as Mean $\pm$ Standard Deviation, intergroup and intragroup comparison studies were carried out through independent-samples T test; in case of nominal data expressed as [n (%)], intergroup and intragroup comparison studies were carried out with X² test. Intragroup comparison at multiple points was analyzed by ANOVA. For all statistical comparisons, significance was defined as $P < 0.05$.

Results

Comparison between the 2 groups for general data

There was no clear difference between the 2 groups in terms of proportions of male and female patients, average age, average course of disease, lumbar stenosis parting, and proportions of concurrent diseases (all $P > 0.05$, **Table 1**).

Comparison between the 2 groups for surgical conditions

There was no statistical difference in operation time, drainage tube indwelling time, intraoperative bleeding volume and postoperative drainage volume between the 2 groups ($P > 0.05$, **Table 2**).

Table 2. Comparison between the OG and the CG for Surgical Conditions ($\bar{x} \pm s$)

Group	n	Operation time (min)	Intraoperative bleeding volume (ml)	Postoperative drainage volume (ml)	Drainage tube indwelling time (d)
OG	19	125.62±42.18	248.95±110.69	178.51±51.43	2.63±1.18
CG	19	131.47±46.93	257.49±112.24	181.25±50.27	2.81±1.22
t		0.404	0.236	0.166	0.462
P		0.689	0.815	0.869	0.647

Table 3. Comparison between the OG and the CG for Bone Graft Fusion [n (%)]

Group	Firm Fusion	Possible Fusion	Non-fusion
OG (n=19)	16 (84.21)	2 (10.53)	1 (5.26)
CG (n=19)	12 (63.16)	5 (26.32)	2 (10.53)
χ^2	2.171	1.576	0.362
P	0.141	0.209	0.547

Comparison between the 2 groups for bone graft fusion

There was no statistically significant difference in terms of firm fusion, possible fusion and non-fusion in the 2 groups ($P>0.05$, **Table 3**).

Comparison between the 2 groups for the implantation failure and loss rate of intervertebral space height

In the OG, there was 1 case (5.26%) of implantation failure and 18 cases (94.74%) of implantation success; while in the CG, the reported failures were 3 (15.79%) and successes were 16 (84.21%). One patient (5.26%) lost the intervertebral space height and 18 patients (94.74%) did not in the OG; while in the CG, the corresponding cases were 4 (21.05%) and 15 (78.95%), respectively. Though the OG reported higher internal implant failure and loss rate of intervertebral space height than the CG, the difference was not statistically significant ($\chi^2=1.118$, 2.073, $P=0.290$, 0.150) (**Figure 1**).

Comparison between the 2 groups for lumbar function

The JOA score for lumbar function before, 1 week, 1 month, 3 months and 6 months after the operation were (13.56±3.38), (17.75±4.19), (17.34±3.94), (23.31±4.16) and (25.34±3.62) respectively, in the OG; and (13.62±3.42), (15.02±3.61), (20.25±4.57), (20.28±3.85) and (22.13±3.28) respectively, in the CG. Showing insignificant differences before the operation,

the OG reported higher points than the CG at 1 month, 3 months and 6 months after the operation ($P<0.05$, **Figure 2**).

Comparison between the 2 groups for dysfunction

In terms of the ODI score for dysfunction before, 1 week, 1 month, 3 months and 6 months after the operation, the reported points were (30.56±10.15), (23.23±7.86), (17.82±4.36), (13.05±3.95) and (8.87±2.16) respectively, in the OG; and (30.62±10.19), (26.78±8.51), (22.31±4.89), (15.89±4.21) and (11.27±2.53) respectively, in the CG. Before operation, the 2 groups demonstrated no significant difference ($P>0.05$), but 1 week, 1 month, 3 months and 6 months after the operation, the OG's ODI scores were significantly lower as compared with the CG ($P<0.05$, **Figure 3**).

Comparison between the 2 groups for QOL

From the perspective of SF-36 score for QOL before, 3 months and 6 months after the operation, the OG yielded points of (76.53±12.28), (126.86±20.13), (169.86±28.78) respectively, in the OG; while they were (74.95±11.76), (114.76±17.89) and (150.39±21.35) respectively, in the CG. Before operation, the 2 groups demonstrated no significant difference ($P>0.05$), but at 3 months and 6 months after the operation, both groups attained an increase, and the OG's QOL scores were significantly higher than the CG ($P<0.05$, **Figure 4**).

Discussion

LST with instability is mostly reported in the middle-aged and elderly populations at a rising incidence due to the severe social aging trend in recent years [13]. The specific characteristics of LST include hyperplasia of intervertebral facet joints, hypertrophic calcification of ligamentum flavum, calcification of posterior longi-

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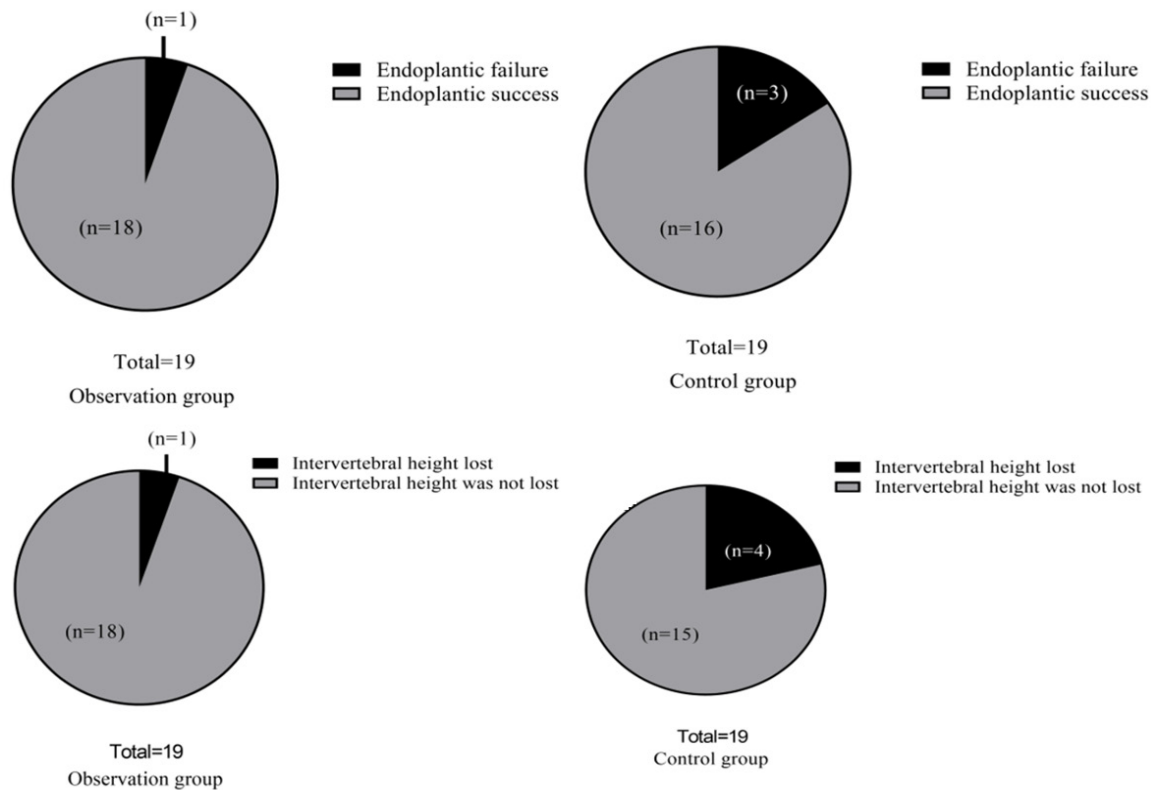


Figure 1. Comparison between the OG and the CG for Internal Implant Failure and Loss of Intervertebral Space Height. No significant difference was observed between the 2 groups in terms of failed and successful cases of internal implant ($P>0.05$), and cases with/without loss in intervertebral space height ($P>0.05$).

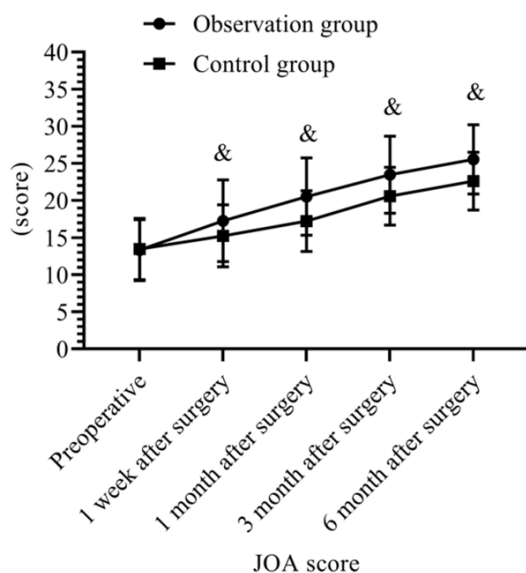


Figure 2. Comparison between the OG and the CG for Lumbar Function JOA Score. Before the operation, no statistical difference was demonstrated between the 2 groups in terms of JOA score ($P>0.05$). 1 week, 1 month, 3 months and 6 months after the operation, the OG reported higher JOA scores than the CG ($P<0.05$). & indicates $P<0.05$ as compared between the 2 groups at the same time point.

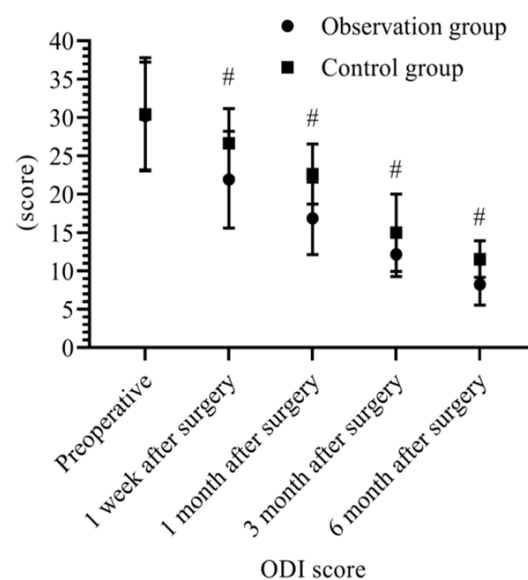


Figure 3. Comparison between the OG and the CG for Dysfunction ODI Score. Before the operation, no statistical difference was found between the 2 groups for the ODI score ($P>0.05$), which, however, were far lower in the OG 1 week, 1 month, 3 months and 6 months after the operation ($P<0.05$). # indicates $P<0.05$ as compared between the 2 groups at the same time point.

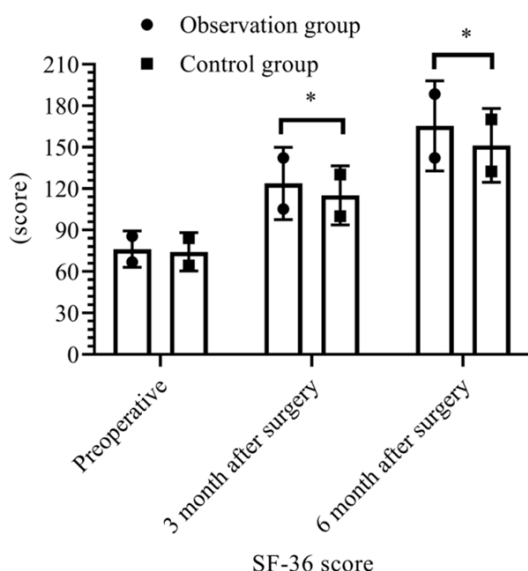


Figure 4. Comparison between the OG and the CG for QOL SF-36 Scores. Compared with the CG before the operation, there was no significant difference in SF-36 score ($P>0.05$). At 3 months and 6 months later, the OG yielded higher scores ($P<0.05$). *indicates $P<0.05$ as compared between the 2 groups at the same time point.

tudinal ligament, and decrease of intervertebral stability. Clinically, it is manifested as numbness, pain, weakness of the lower extremities, or angina cruris in some cases [14]. Pawar SG et al [15] reported that around 1/5 of the patients seeking a doctor's advice because of pains in waist or leg were concurrently suffering from lumbar instability, while in another case, they may also experience spinal instability due to the lumbar spinal stenosis as a result of lumbar degeneration. Lumbar instability will severely impact patients' life and reduce their quality of life.

A majority of the patients with LST and instability received conservative treatment to alleviate the syndromes, but about 1/4 of them were not relieved and demanded surgical treatment. So far, the spinal interbody fusion is a common treatment widely applied in the clinical for LST and instability with evident efficacy [16, 17]. In this study, Patients in the OG received posterior lumbar spinal canal decompression, intervertebral bone grafting and internal fixation, whose advantages lie in the implantation of an interbody fusion cage to provide effective support to the parastyle and the column of the spine. The pedicle screw rod functions as a tension band

to prevent various concurrent diseases such as displacement and loosening, etc. [18]. In addition, the pedicle screw rod can secure the instable centrams to maximally recover the original rigidity, while the interbody fusion cage can provide effective axial load between centrams, so as to partially disperse some of the stress on the pedicle screw rod, and consequently, reduce the risk of complications such as a loose or broken pedicle screw rod in case only one is applied [19, 20]. The internal fixation system with pedicle screw rod, and its combination with the cage could recover the mechanical structure of the spine, the intervertebral height, the intervertebral hole capacity as far as possible, but also reduce the pressure on the nerve root canals, and vertebral canals [21]. In their studies, Doulgeris JJ et al [22] found that, compared with patients in whom no cage was applied, patients in whom the pedicle screw system was combined with the cage reported higher fusion rate, more significant recovery of intervertebral space height, and better clinical efficacy. Tomycz L et al [21] testified in their study that the application of the cage could realize the synchronous fusion of the parastyle and the column at the lumbar vertebra, stabilize intervertebral space immediately, reduce long-term possible intervertebral space collapse, and recover the lumbar vertebra to allow physiological bending.

Except for the posterior lumbar spinal canal decompression, intervertebral bone grafting and internal fixation, the key points included whether the posterior lumbar spinal canal could be thoroughly decompressed, if the pressure at the nerve root canal area can be thoroughly reduced, and then more attention is required on the reconstruction of spinal stability to harvest satisfactory long-term effects [23]. According to previous clinical applications, it can be learned that the advantages of intertransverse bone grafting and fusion are decompression at the same time, short distance from the movable fulcrum of lumbar vertebra to extend and curve to the bone graft, and abundant blood transfusion benefiting the bone graft fusion [24, 25]. Furthermore, the intertransverse bone grafting contributes to improved stability after spinal reconstruction through extensive decompression at the rear side. In this study, the OG and the CG had no statistical difference in terms of the operation

time, drainage tube indwelling time, intraoperative bleeding volume and postoperative drainage volume ($P>0.05$), indicating that both surgeries can ensure good surgical effects. He YQ et al [26] revealed in their study that compared with intertransverse bone grafting combined with internal fixation, the lumbar intervertebral bone grafting combined with internal fixation was characterized by higher infusion rate and lower internal implant failure. The OG reported a higher fusion rate than the CG, lower internal implant failure and loss rate of intervertebral space height, which, however, were not statistically significant due to the small sample size in this study. The OG's lumbar function and dysfunction scores 1 week, 1 month, 3 months and 6 months after the operation, and QOL scores 1 month and 3 months after the operation were more outstanding ($P<0.05$), certifying that compared with the intertransverse bone grafting combined with internal fixation, the lumbar intervertebral bone grafting combined with internal fixation could achieve more dominant long-term efficacy, alleviate patients' dysfunction quickly, and improving the lumbar function fast to achieve better quality of life.

In conclusion, both methods worked on patients with LST and instability, but in comparison, the lumbar intervertebral bone grafting combined with internal fixation is more capable and worthy of popularization because it can improve patients' fusion rate, reduce internal implant failure, and greatly ameliorate patients' lumbar function and quality of life. However, this study included less than optimal study subjects to comprehensively analyze the study results, and the results obtained were somewhat biased. The future studies will be based on a larger sample size, investigate more aspects more in depth, and be more forward looking to as to obtain more scientific and representative conclusions to give more guides on the surgeries of patients with LST and instability.

Disclosure of conflict of interest

None.

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